Report for 2004TN13B: An Investigation of Surface-Ground Water Connections at Nonconnah Creek: A Source of Recharge and Potential Contamination for the Memphis Aquifer in Shelby County Tennessee

- Articles in Refereed Scientific Journals:
  - Larsen, D, R W Gentry, D K Solomon, 2003, The geochemistry of mixing of leakage in a semi-confined aquifer at a minicipal well field, Memphis, Tennessee, USA, Applied Geochemistry, 18, 1043-1063.
- Conference Proceedings:
  - Larsen, D, J Morat, B Waldron, S Ivey, J Anderson, A Owen, C Garner, 2005, Hydrologic assessment of leakage from Nonconnah Creek to the shallow aquifer in the vicinity of the Sheahan well field, Memphis, Tennessee, "in" Proceedings of the Fifthteenth Tennessee Water Resources Symposium, April 13-15, 2005, Burns, TN, 2B-15.

Report Follows

Problem and Research Objectives:

This project investigates the potential of surface water from an impaired watershed (Nonconnah Creek, Fig. 1) to infiltrate into a shallow aquifer system that recharges an aquifer (Memphis aquifer) used for a municipal water supply. This project is an expansion of a long-term study to investigate the potential for modern water to enter the Memphis aquifer in the Sheahan well field, Memphis, Tennessee (Fig. 2). Published results of our previous research indicate that water pumped from shallow production wells in the Memphis aquifer contains as much as 30% of a chemically distinct modern water (15 to 20 year residence time) that is entering the upper part of the Memphis aquifer near the Sheahan well field. The shallow aquifer overlying the upper Claiborne confining unit and Memphis aquifer is almost unsaturated near the Sheahan pumping station, but becomes progressively saturated toward Nonconnah Creek, 2.7 miles south of the pumping station. Previous investigators determined that Nonconnah Creek loses water to the shallow aquifer in the Memphis area, although no quantitative information is available. Most recently, lumped parameter tracer models have been coupled with inverse computational methods and geochemical data to determine fluxes of modern water to individual well and a location of leakage from the shallow aquifer in the center of the well field. Unpublished finite-difference flow modeling results and model calibration further suggest that various wells in the Sheahan well field receive water from the shallow aquifer, most likely ultimately derived from Nonconnah Creek. Considering that Nonconnah Creek receives urban and agricultural runoff and contains significant pollutant loadings and that the shallow aquifer beneath Nonconnah Creek contains agricultural pollution, it is important to assess shallow aquifer contributions to the urban water supply. The results of the project have the potential to influence ground-water exploitation strategies, watershed management, and source-water protection policies in the Memphis area and surrounding region.

The prime objective of this study is to determine whether Nonconnah Creek is a losing stream in the region south of the Sheahan well field and, if so, how much of that water could be contributing to recharge of the Memphis aquifer at the Sheahan well field. The water loss from Nonconnah Creek to ground water is assessed using four types of methods: (1) hydraulic data and ground-water flow modeling (stream gaging and head measurements), (2) water chemistry (major and minor solutes) and organic chemical analysis, (3) environmental tracers ($^{3}H/^{3}He$ and CFC's), and (4) groundwater flow modeling.

Methods and Accomplishments:

The project is designed to determine the flux and quality of water from Nonconnah Creek to the shallow aquifer during a one-year period (Spring 2004 –Spring 2005). Currently, most of our installation, sampling, and modeling milestones in the project development have been met. Three monitoring wells (NC-1, -2, and -3) were installed and developed in the shallow aquifer in the vicinity of Nonconnah Creek and Getwell Road during April 2004. The boreholes were drilled using a hollow-stem and the returns were described and sampled in the field. The samples are being analyzed for their grain-size distributions. In addition, a stilling well was installed at the same location in August 2004. All well locations and elevations were surveyed using a nearby survey point. Pressure transducers were installed in two of the monitoring wells and in the stilling well. As part of a larger transducer network in Shelby County, pressure transducers are also installed in three existing monitoring wells in the Sheahan well field. Water levels in the wells are being taken quarterly (May and August, 2004) along with discharge measurements in Nonconnah Creek and Johns Creek, a major tributary upstream from the Getwell Road site. Slug testing (for estimating hydraulic conductivity) of 5 wells has been completed: 3 wells (NC-1, SH:K-75, and MLGW 99s) were tested during July 2004 and 2 additional wells (NC-2 and –3) were tested during class projects for a Field Methods in Hydrology course in

October 2004. Water quality samples were also taken from 6 wells and Nonconnah Creek during May, August, and November 2004 and March 2005. In addition to field analysis using calibrated probes, titration, and spectrophotometric techniques, lab analysis of anion concentrations by ion chromatography and cation concentrations by flame source atomic absorption spectrometry have been completed on all but the March 2005 samples (only cation analysis remains). The three monitoring wells at Nonconnah Creek and three shallow monitoring wells in the Sheahan well field were sampled for tritium, noble gases (including ^{3}He) and Chlorofluorocarbons (CFC's) during August 2004; a tritium sample was also taken from Nonconnah Creek as well. In regard to model development, boundary conditions and hydraulic head data have been estimated from existing hydraulic data. A geologic structure was estimated from well-log data and was transformed into a 55-layer model; however, the model would not calibrate due to dry cells. A less complex model comprising fewer layers is currently being calibrated and tested.

Principal Results and Significance

The data collected thus far indicate substantial leakage from Nonconnah Creek to the alluvial aquifer and potential for ground-water flow from the alluvial aquifer to the Memphis aquifer. Downstream stream losses have been determined during each series of discharge measurements and average 0.66 million gallons per day (MGD)(Fig. 1). Vertical downward gradients are consistently measured in the stilling well and three wells constructed in the alluvial aquifer at Nonconnah Creek and Getwell Rd. Water table maps for the four water-level measurements indicate a consistent gradient from Nonconnah Creek to the center of the Sheahan well field (Fig. 2). Using hydraulic characteristics of the shallow aquifer, a resulting flow of 0.4 MGD from the alluvial aquifer near the creek to the fluvial aquifer beneath the well field. Geochemical data indicate that water quality generally varies with distance from Nonconnah Creek; however, water compositions in Nonconnah Creek are similar to those in MLGW 99s and production wells sampled in the Sheahan well field in 2002 (Fig. 3). The latter observations suggest that a preferential flow path may exist between Nonconnah Creek and the Sheahan well field, possibly an ancient paleochannel in the shallow aquifer as suggested in previous studies (Larsen et al., 2003). Tritium-^{3}He ground-water ages from shallow aquifer wells vary from approximately 14 to 29 yrs, generally increasing with distance from the creek to the center of the aquifer. An exception to the increasing age trend is observed in well MLGW 96s (14 yrs), which lies close to the trend of the ancient paleochannel. The CFC data are still being evaluated.

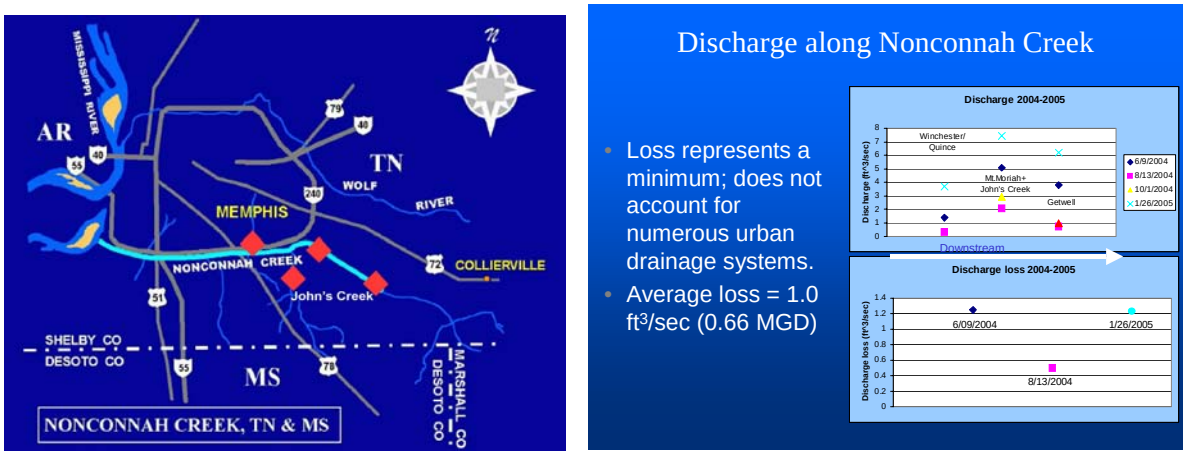

Fig. 1. (A) Location of discharge measurement locations along Nonconnah Creek. (B) Discharge data and calculation of average loss (MGD = million gallons per day).

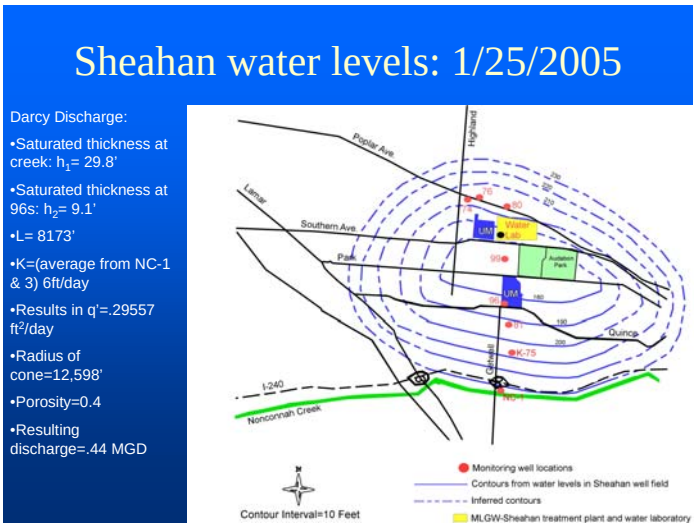

Fig. 2. Water table map and calculated loss from Shallow aquifer to Memphis aquifer.

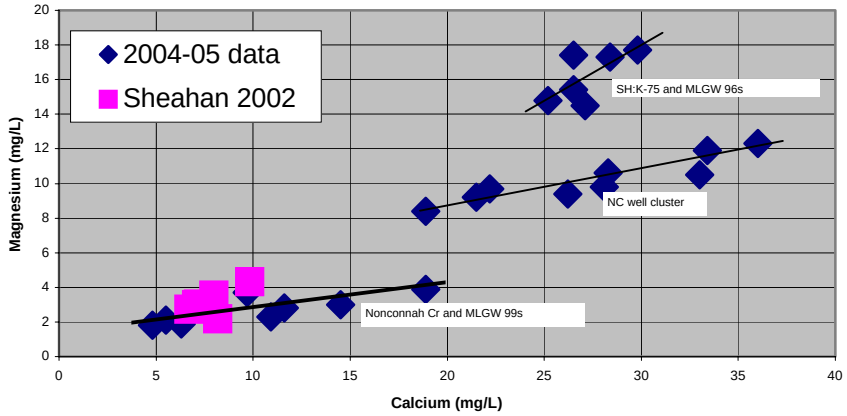

Fig. 3. Example of geochemical results from 2004-2005 Nonconnah Creek project in comparison to Sheahan well field data from 2002.

The study serves as the Masters thesis project for Jason Morat, a student in the Department of Earth Sciences at the University of Memphis. Jason has been trained in all measurements, sampling protocols, and analytical methods associated with the project, and is conducting much of the work with other graduate students and myself. Jason presented preliminary results of the study at the Tennessee section of the American Water Resources Association in April 2005. As many as 7 or 8 students working at the Ground Water Institute during the Spring, Summer, and Fall 2004 have been involved with various aspects of the project, including well construction, stream gaging, water-level measurements, water sampling, and chemical analysis. Several of the field projects conducted in Field Methods in Hydrology, taught by Dr. Larsen during the fall semester 2004, have taken place at the Nonconnah Creek and Getwell Rd. well cluster or in Nonconnah Creek itself. The ten students in the

class measured stream discharge and water quality, and conducted slug testing of wells associated with the Nonconnah research project.

Future Research and Funding:

- A study to re-evaluate the water table in Shelby County has received funding from TDEC and Shelby County for 2005-2006.

- A study to evaluate the presence of modern water in municipal well field in Shelby County is currently being funded by the Shelby County Department of Health.